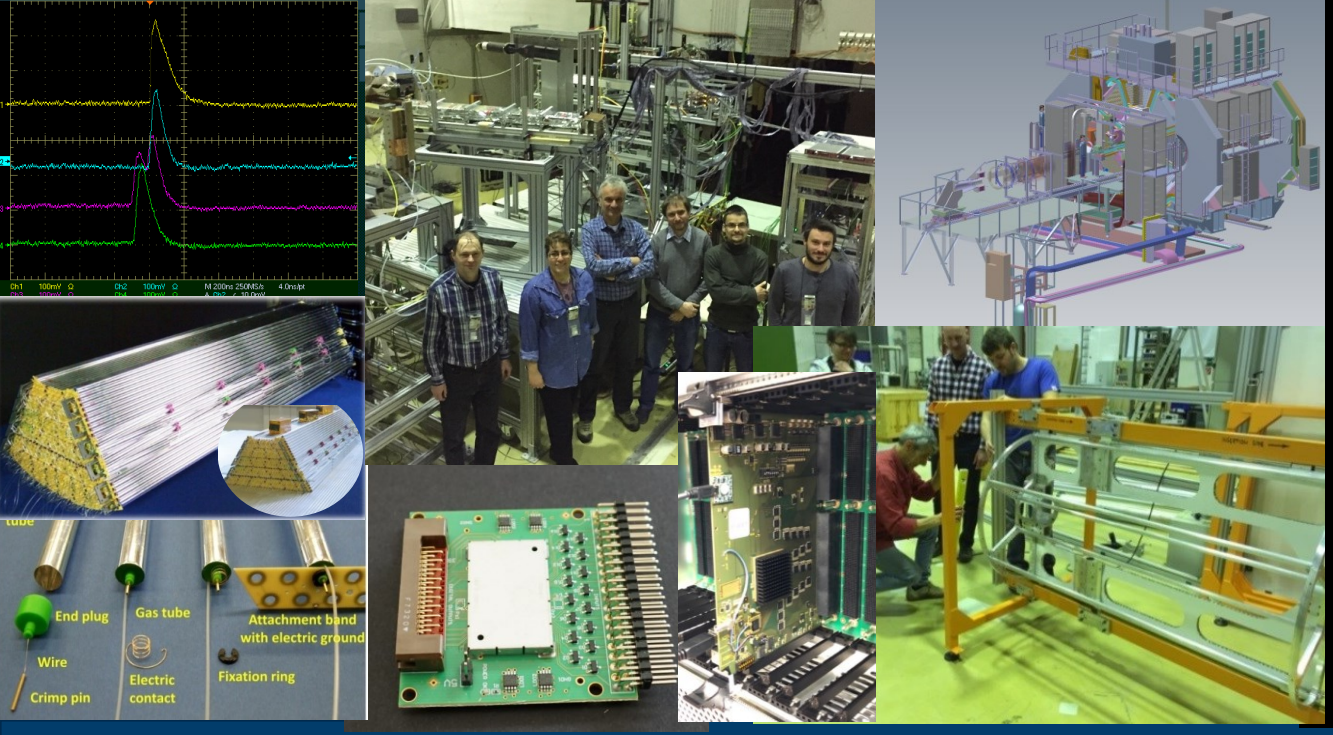


ASIC/TRB3 RESULTS STT

NOV-7, 2018 | PETER WINTZ (FOR THE STT GROUP)

OUTLINE ASIC/TRB3 RESULTS

Time and Time-over-Threshold Measurement

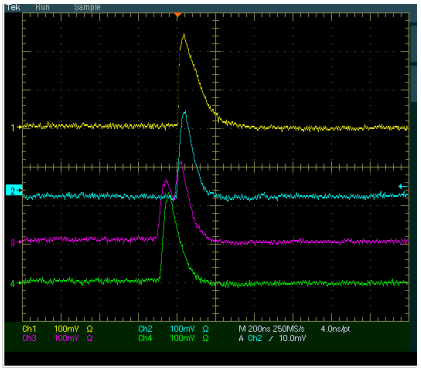
- Testbeams
- Calibration & tracking
- Spatial resolution
- PID methods
- PID results

TESTBEAMS IN 2016 & 2018

- Proton and deuteron beams at COSY, momentum range: 0.5 - 3.0 GeV/c
- Covered dE/dx range: ~ 5 - 50 keV/cm (= 1-10× MIP, in Ar/CO_2 at 2 bar)
- Setups with 24 straws per layer, several layers readout
- Two gas mixtures: Ar/CO2(10%) → 150ns tmax, Ar/CO2(20%) → 220ns tmax
- Tracks with (>) 24 hits, similar to PANDA-STT

One of the two straw test systems. Beam enters from the right.

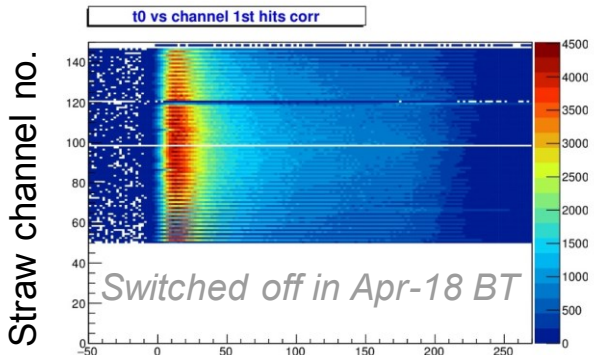
Test setups in new beam area. Beam from the back with ~2m beam line height.

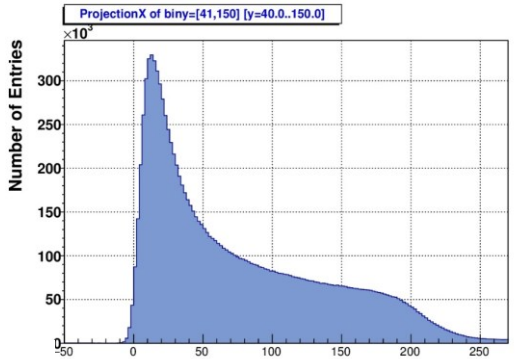


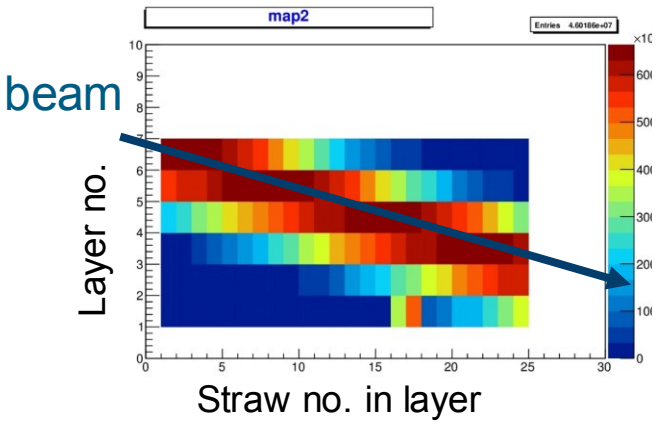
Straw signals (in-beam)

CALIBRATION & TRACKING

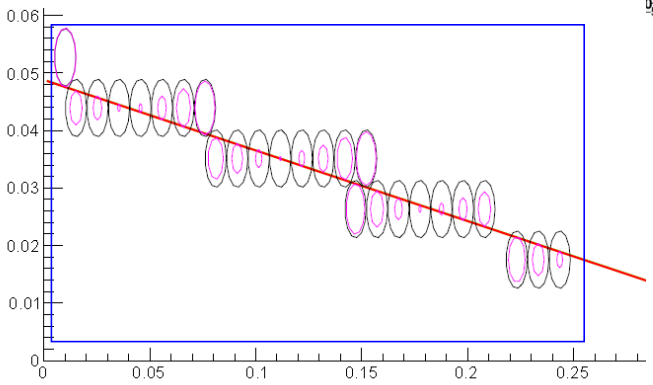
- Calibration isochrone radius *r(t)* $\frac{N}{R} = \frac{\sum n_i}{r(t_i)} \rightarrow r(t) = \sum P_i \times t^i$
- 1st tracking, χ2- fit to isochrones
- Re-calibration with reco tracks (iterative)
  - Track-wire distance $\leftrightarrow$ meas. drift time $\rightarrow$ r(t)
  - Residual distribution, mean shifted ? $\rightarrow$ r(t) shift by R_0=P_0
- Final tracking
  - Hit filter, reject single outliers (e.g. ~ 15% δ-electr.)



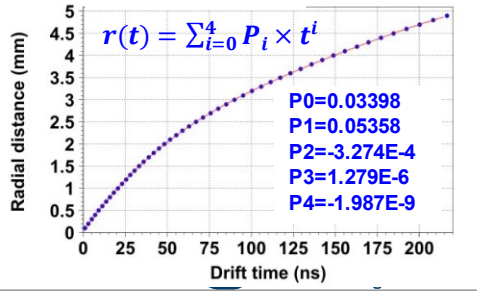




Track reconstruction (testbeam data)

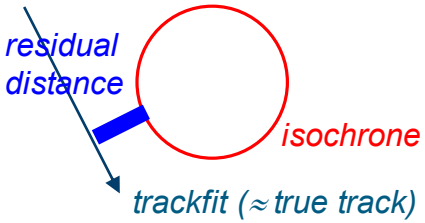


r(t) relation

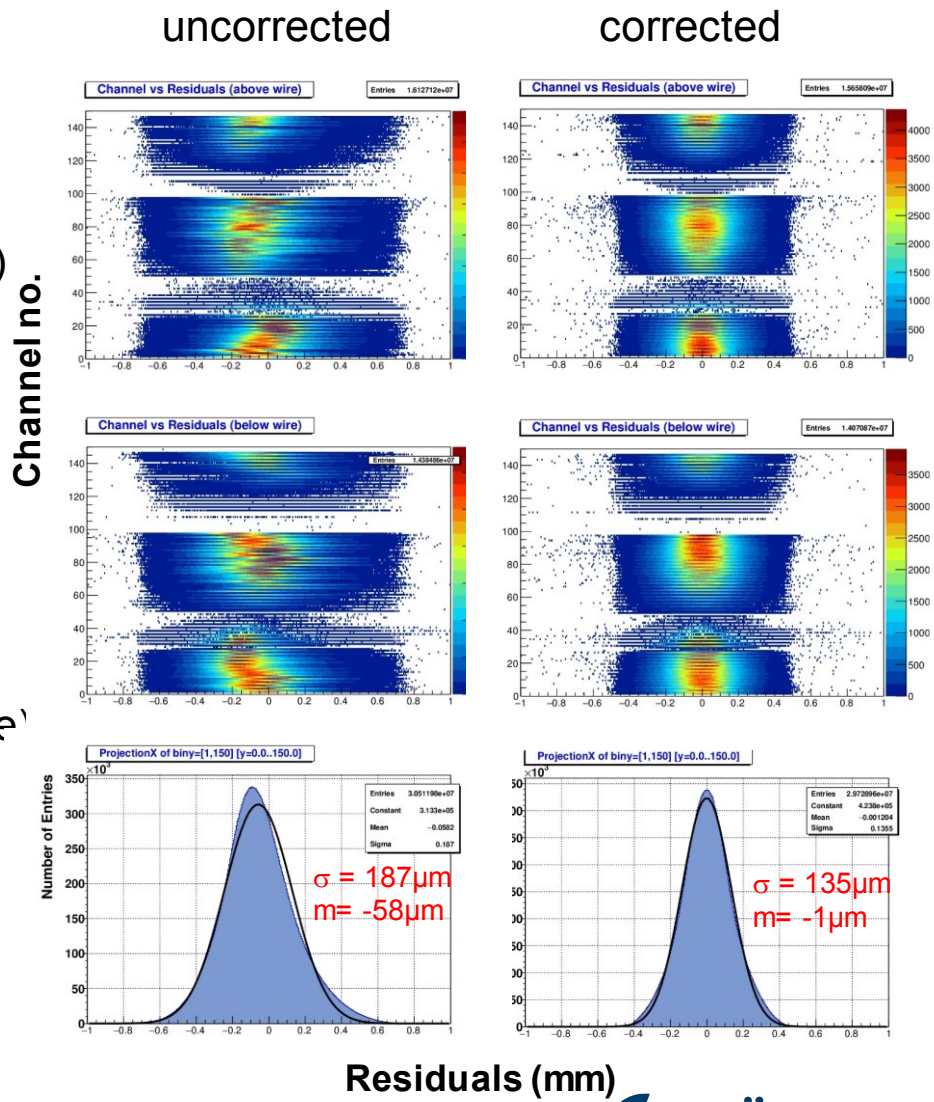


R(T) CALIBRATION & ITERATION

- Reconstruct tracks with uncorrected r(t)
- Determine residual shifts (above/below wire)



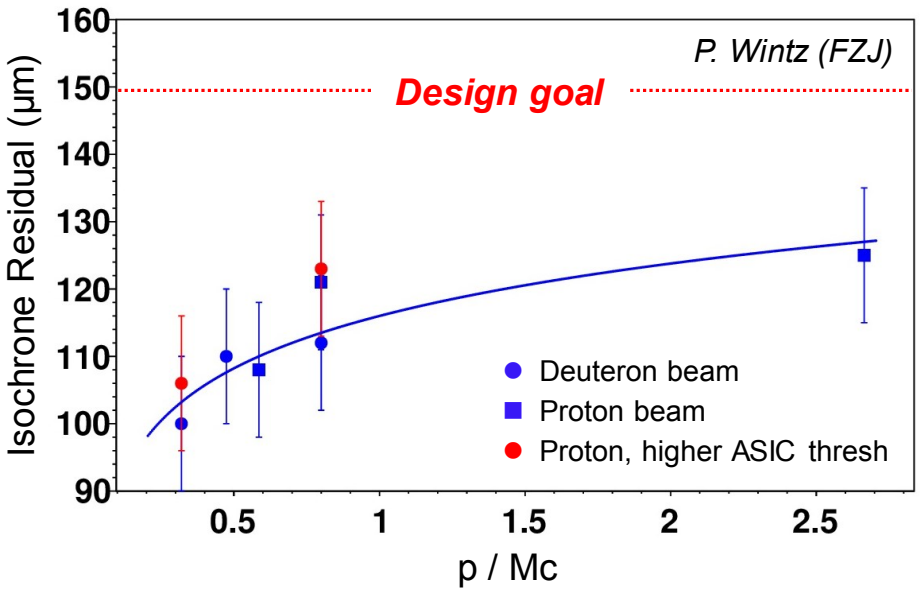
- Add R_0 to r(t), re-fit, iterate .. (auto procedure)
- Improved residual spread and symmetry
- Global r(t) used, R_0 shifts for individ. channe

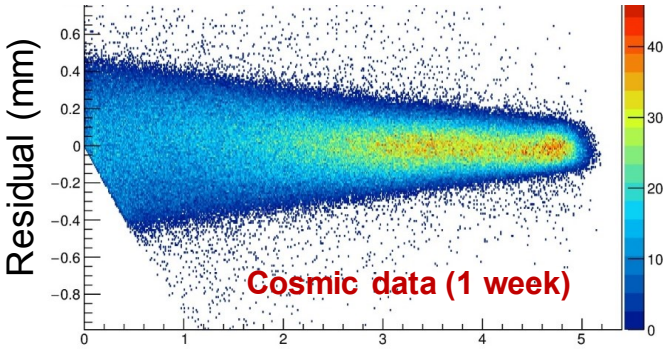


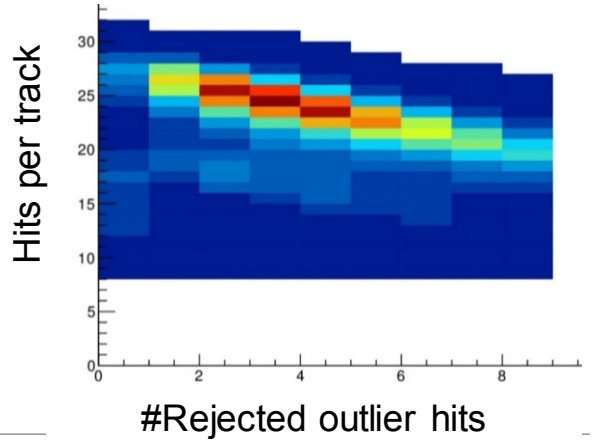
SPATIAL RESOLUTION RESULTS

ASIC/TRB3

- Proton and deuteron data (2016 & 2018), large dE/dx range covered (~1-10 x mips)
- Results far better than design goal (150 µm) → confidence for STT at PANDA
- Hit filter: reject single outliers (~15%, e.g. δ-electrons)
- Measurements at worst location (sag at tube middle)
- ASIC basic setting: gain=1, pkt=20ns, thresh=10mV, ..







PID OBSERVABLE (1)

Time-over-Threshold, Time Corrected

- ToT is drift time dependent ($v_{drift} \propto 1/r$)
- ToT vs drift time, polynomial fit

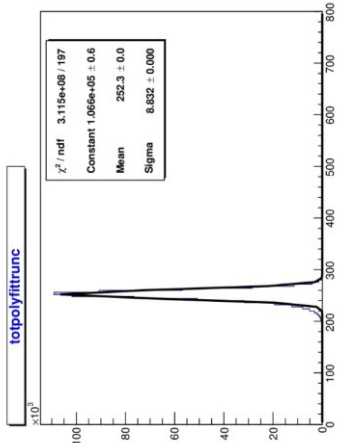
$$ToT(t_{dr}) = \sum_{i=0}^{4} P_i \times t_{dr}^{i}$$

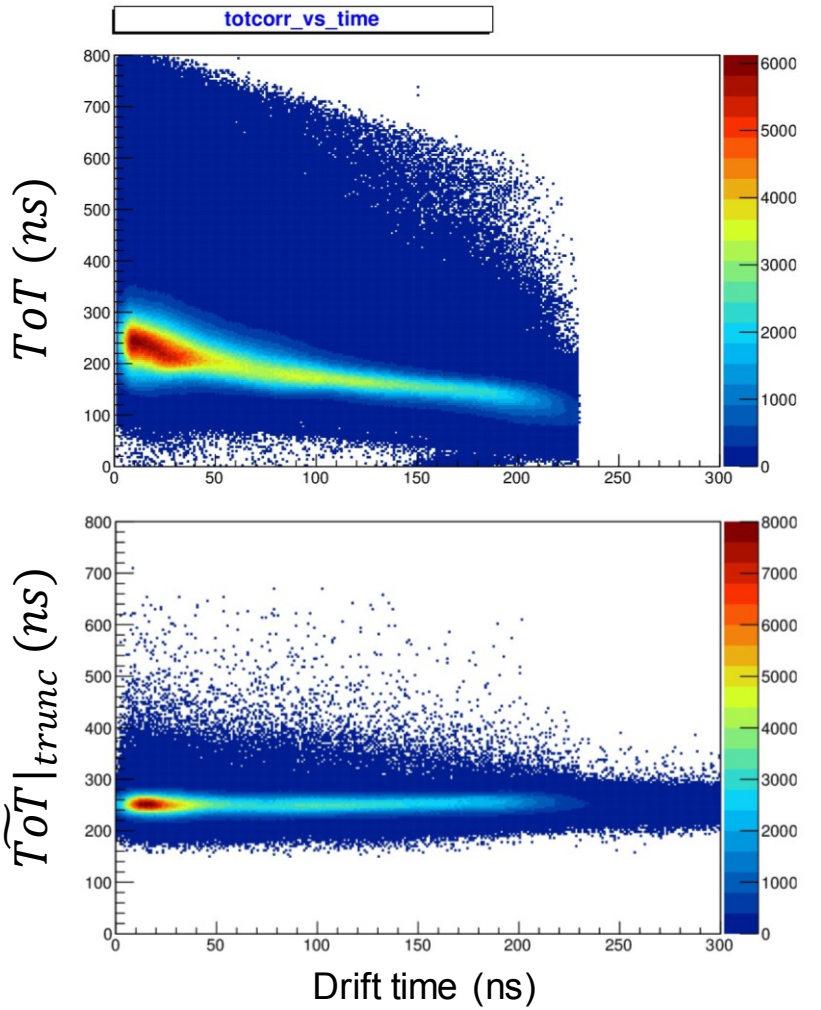
$$ToT(t_{dr}) \rightarrow ToT(t_{dr} = 0) \equiv \widetilde{ToT}$$

- Truncated mean (~ 30 % highest hits)

$$\widetilde{ToT}|_{trunc}$$

- Drift times needed (t0)
- Track specific (dE/dx)



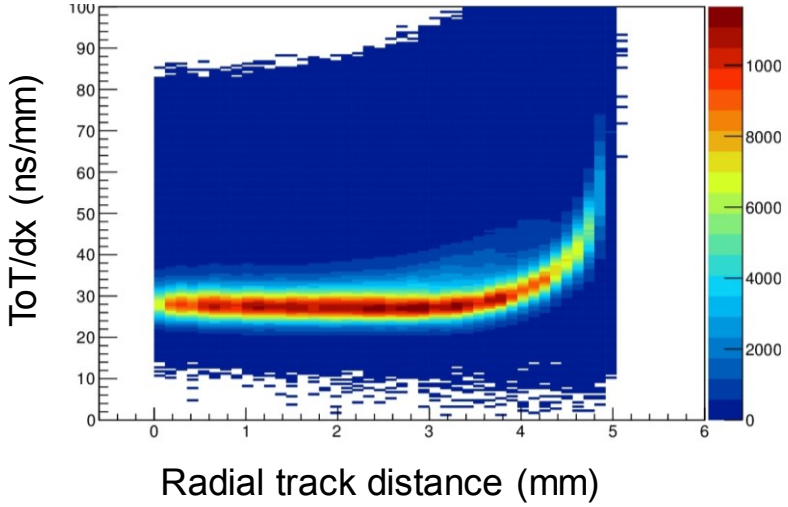


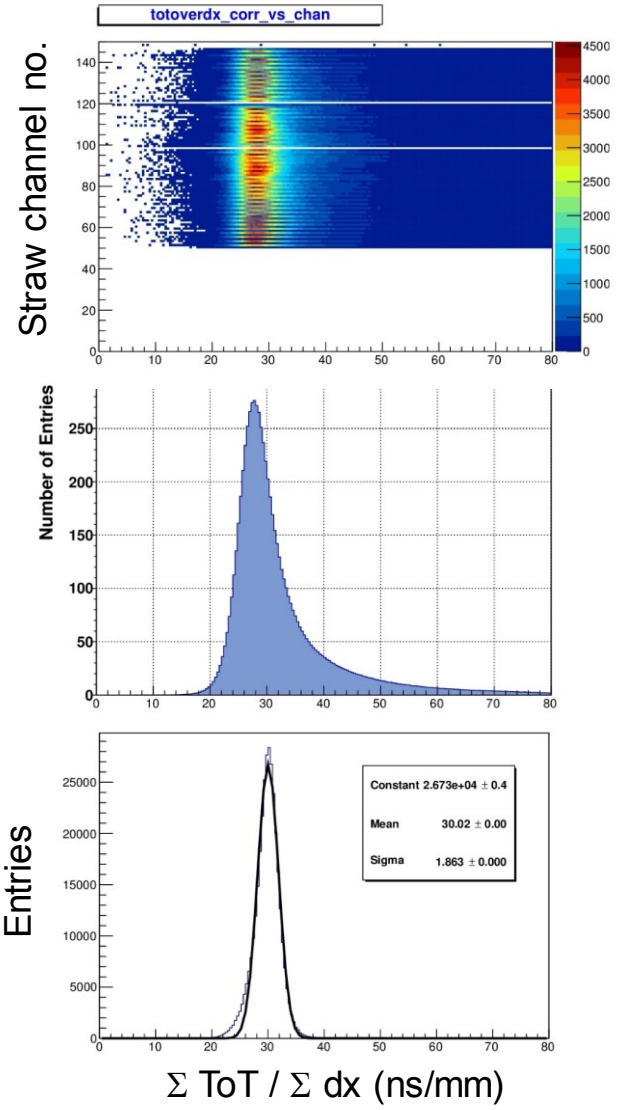
PID OBSERVABLE (2)

Time-over-Threshold / Tracklength

- ToT/dx almost constant over r = 0 – 4 mm
- $\frac{\sum_{hits} ToT}{\sum_{hits} dx}$ better (averaging) than $\sum_{hits} \frac{ToT}{dx}$
- Truncate Landau-tail (~ 30% of highest hits)

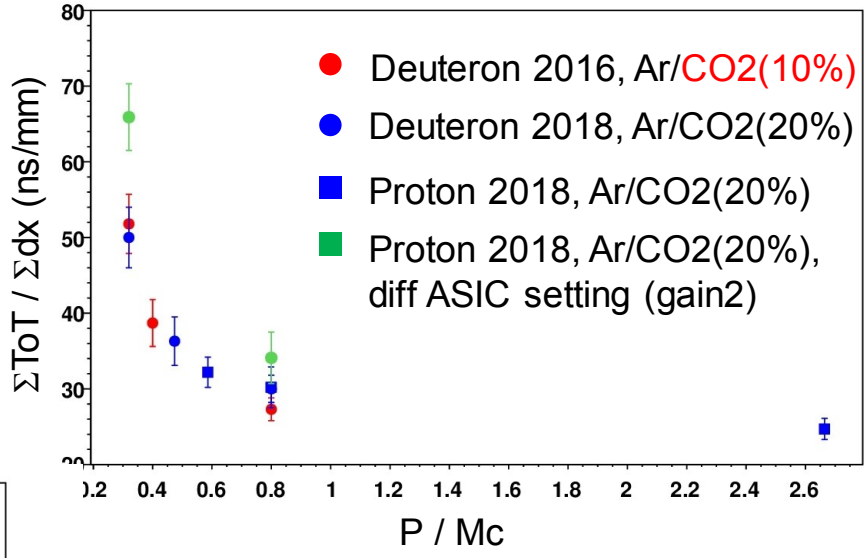
- ToT raw data sufficient (no t0 needed)
- Coarse tracking for dx sufficient

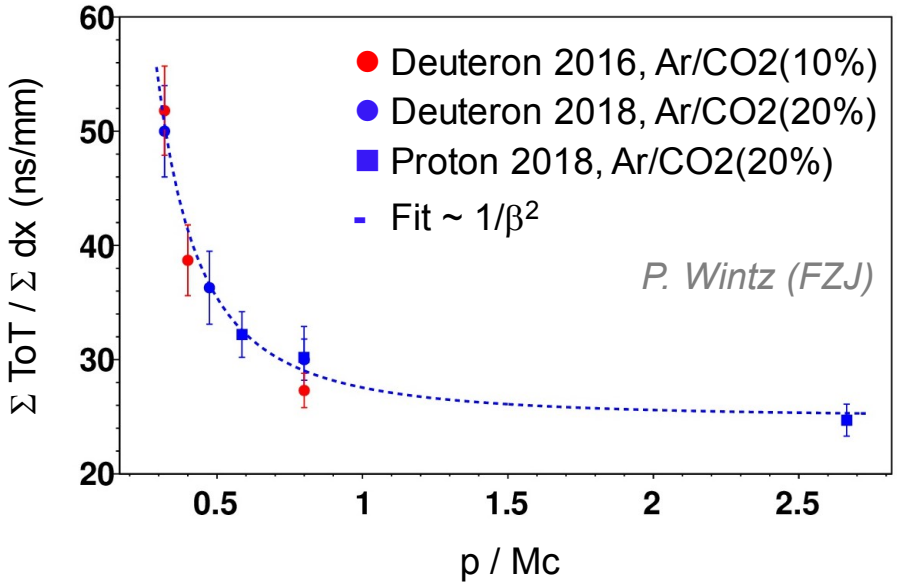




TOT PID RESULTS

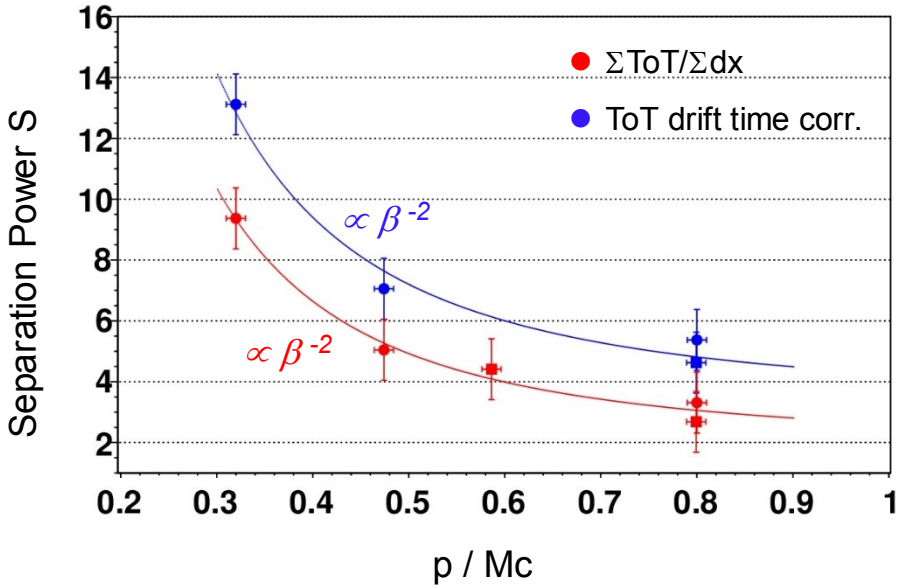
- Proton & deuteron data, 2016 & 2018
- Two gas mixtures CO2 10% & 20%
- ASIC BL, NL and low thresholds stable
- Different ASIC parameters checked
- ToT/dx with β^{-2} dependence





PID OBSERVABLES

- Separation power S versus β for proton and deuteron data
- Proton at 2.5 GeV/c as reference (=mip)



- Which observables is best for S ?

- ΣToT/Σdx (red)
  - raw ToT data, no precise t0 needed
  - coarse tracking for dx sufficient
  - suited for online determination

- ToT $|_{\text{time correc.}}$ (blue)
  - precise t0 knowledge needed
  - parametrisation ToT as function of drift time, track specific (dE/dx)

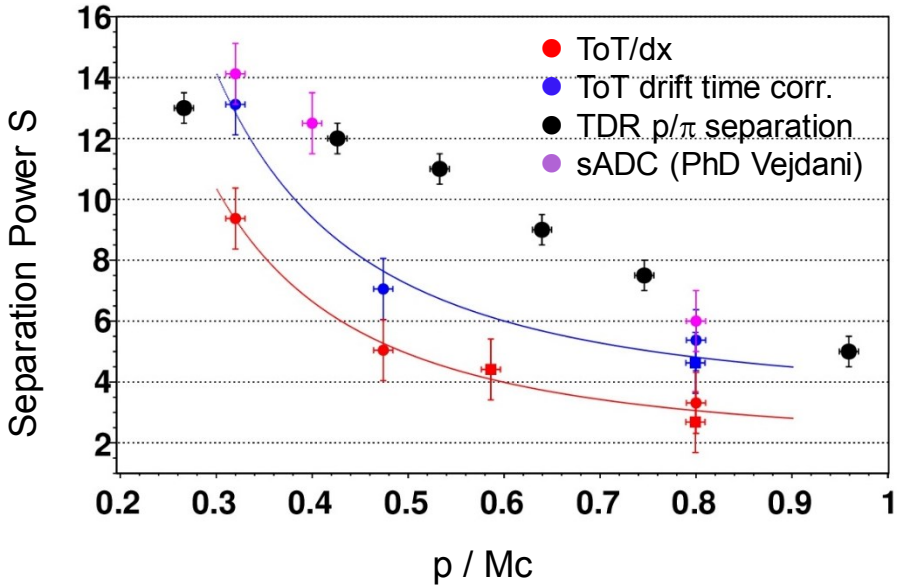
$$Separation\ Power\ S = \frac{\langle M_1 \rangle - \langle M_2 \rangle}{(\sigma_1 + \sigma_2)/2}$$

PID RESULTS

- Proton separation power compared with TDR p/π separation simulation results (black)
  - pions minimum ionising, but dip $\rightarrow$ not exactly comparable

- Similar separation at $\beta \sim 0.9$ *and* $\beta \sim 0.3$
- Difference around $\beta \sim 0.5$ (π - dip)

- Comparison with sADC data (purple)
  - Prototype FADC (240 MHz)
  - Pre-series system data not yet available



SUMMARY

- ASIC performance results inline with design goals for spatial resolution and PID
- ASIC default setting established (out of > 6000 sets)
- Full dE/dx range covered by testbeams at COSY
- Stable ASIC & TRB3 operation during period 2016-18 (low NL, low thresholds, ..)

- Further investigations ongoing
  - Individual BL tuning and amplitude/time-over-threshold variation
  - Signal propagation along wire and track angle dependence

- Mechanical frontend-layout for STT challenging
  - Limited space, ~ 1cm FEB spacing, cooling scheme
  - Final design to be done

Thank you

for your

attention